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1 Fair scheduling with tunable latency: a round-robin approach

Hemant M. Chaskar, Upamanyu Madhow

August 2003 **IEEE/ACM Transactions on Networking (TON)**, Volume 11 Issue 4

Full text available: pdf(565.62 KB) Additional Information: full citation, abstract, references, index terms

Weighted fair queueing (WFQ)-based packet scheduling schemes require processing at line speeds for tag computation and tag sorting. This requirement presents a bottleneck for their implementation at high transmission speeds. In this paper, we propose an alternative and lower complexity approach to packet scheduling, based on modifications of the classical round-robin scheduler. Contrary to conventional belief, we show that appropriate modifications of the weighted round-robin (WRR) service disci ...

Keywords: quality of service, round robin, scheduling, weighted fair queueing

2 SRR: An O(1) time complexity packet scheduler for flows in multi-service packet networks

Guo Chuanxiong

August 2001 **ACM SIGCOMM Computer Communication Review , Proceedings of the 2001 conference on Applications, technologies, architectures, and protocols for computer communications**, Volume 31 Issue 4

Full text available: pdf(321.72 KB) Additional Information: full citation, references, citings, index terms

Keywords: QoS, complexity, end-to-end delay, fair queueing, high speed networks, packet scheduler

3 Efficient fair queueing using deficit round-robin

M. Shreedhar, George Varghese

June 1996 **IEEE/ACM Transactions on Networking (TON)**, Volume 4 Issue 3

Full text available: pdf(1.57 MB) Additional Information: full citation, references, citings, index terms

4 Efficient fair queueing using deficit round robin

M. Shreedhar, George Varghese
October 1995 **ACM SIGCOMM Computer Communication Review , Proceedings of the conference on Applications, technologies, architectures, and protocols for computer communication**, Volume 25 Issue 4

Full text available: pdf(1.17 MB) Additional Information: full citation, abstract, references, citings, index terms

Fair queuing is a technique that allows each flow passing through a network device to have a fair share of network resources. Previous schemes for fair queuing that achieved nearly perfect fairness were expensive to implement: specifically, the work required to process a packet in these schemes was $O(log(n))$, where n is the number of active flows. This is expensive at high speeds. On the other hand, cheaper approximations of fair queuing that have been reported in the ...

5 Latency-rate servers: a general model for analysis of traffic scheduling algorithms
Dimitrios Stiliadis, Anujan Varma
October 1998 **IEEE/ACM Transactions on Networking (TON)**, Volume 6 Issue 5

Full text available: pdf(470.40 KB) Additional Information: full citation, references, citings, index terms

Keywords: delay bounds, fair queueing algorithms, performance bounds, traffic scheduling

6 Design and analysis of frame-based fair queueing: a new traffic scheduling algorithm for packet-switched networks
Dimitrios Stiliadis, Anujan Varma
May 1996 **ACM SIGMETRICS Performance Evaluation Review , Proceedings of the 1996 ACM SIGMETRICS international conference on Measurement and modeling of computer systems**, Volume 24 Issue 1

Full text available: pdf(1.42 MB) Additional Information: full citation, abstract, references, citings, index terms

In this paper we introduce and analyze *frame-based fair queueing*, a novel traffic scheduling algorithm for packet-switched networks. The algorithm provides end-to-end delay bounds identical to those of PGPS (packet-level generalized processor sharing), without the complexity of simulating the fluid-model system in the background as required in PGPS. The algorithm is therefore ideally suited for implementation in packet switches supporting a large number of sessions. We present a simple im ...

7 The iSLIP scheduling algorithm for input-queued switches
Nick McKeown
April 1999 **IEEE/ACM Transactions on Networking (TON)**, Volume 7 Issue 2

Full text available: pdf(282.39 KB) Additional Information: full citation, references, citings, index terms

Keywords: ATM switch, IP router, crossbar switch, input-queueing, scheduling

8 Congestion control & scheduling: Reduced state fair queuing for edge and core routers
Ramana Rao Kompella, George Varghese
June 2004 **Proceedings of the 14th international workshop on Network and operating systems support for digital audio and video**

Full text available: pdf(109.03 KB) Additional Information: full citation, abstract, references, index terms

Despite many years of research, fair queuing still faces a number of implementation challenges in high speed routers. In particular, in spite of proposals such as DiffServ, the state needs for even simple schedulers are still large for heavily channelized core routers and for edge routers. An earlier proposal, Stochastic Fair Queuing, reduces state but at the expense of added unfairness between certain flows. Another earlier scheme, Core Stateless Fair Queuing, requires header changes and does n ...

Keywords: fair queuing, quality of service, scheduling

9 CPU reservations and time constraints: efficient, predictable scheduling of independent activities

Michael B. Jones, Daniela Roşu, Marcel-Cătălin Roşu

October 1997 **ACM SIGOPS Operating Systems Review , Proceedings of the sixteenth ACM symposium on Operating systems principles**, Volume 31 Issue 5

Full text available: pdf(2.25 MB) Additional Information: full citation, references, citings, index terms

10 Borrowed-virtual-time (BVT) scheduling: supporting latency-sensitive threads in a general-purpose scheduler

Kenneth J. Duda, David R. Cheriton

December 1999 **ACM SIGOPS Operating Systems Review , Proceedings of the seventeenth ACM symposium on Operating systems principles**, Volume 33 Issue 5

Full text available: pdf(1.81 MB) Additional Information: full citation, abstract, references, citings, index terms

Systems need to run a larger and more diverse set of applications, from real-time to interactive to batch, on uniprocessor and multiprocessor platforms. However, most schedulers either do not address latency requirements or are specialized to complex real-time paradigms, limiting their applicability to general-purpose systems.In this paper, we present *Borrowed-Virtual-Time (BVT) Scheduling,* showing that it provides low-latency for real-time and interactive applications yet weighted sharin ...

11 Credit-based fair queueing (CBFQ): a simple service-scheduling algorithm for packet-switched networks

Brahim Bensaou, Danny H. K. Tsang, King Tung Chan

October 2001 **IEEE/ACM Transactions on Networking (TON)**, Volume 9 Issue 5

Full text available: pdf(282.71 KB) Additional Information: full citation, abstract, references, index terms

This paper proposes a simple rate-based scheduling algorithm for packet-switched networks. Using a set of counters to keep track of the credits accumulated by each traffic flow, the bandwidth share allocated to each flow, and the size of the head-of-line (HOL) packets of the different flows, the algorithm decides which flow to serve next. Our proposed algorithm requires on average a smaller complexity than the most interesting alternative ones while guaranteeing comparable fairness, delay, and d ...

Keywords: Fair queueing, packet scheduling, quality of service, traffic control

12 Distributed fair scheduling in a wireless LAN

Nitin H. Vaidya, Paramvir Bahl, Seema Gupta

August 2000 **Proceedings of the 6th annual international conference on Mobile computing and networking**

Full text available: pdf(1.22 MB) Additional Information: full citation, abstract, references, citings, index

terms

Fairness is an important issue when accessing a shared wireless channel. With fair scheduling, it is possible to allocate bandwidth in proportion to weightsof the packet flows sharing the channel. This paper presents a fully distributed algorithm for fair scheduling in a wireless LAN. The algorithm can be implemented without using a centralized coordinator to arbitrate medium access. The proposed protocol is derived from th ...

13 A reconfigurable hardware approach to network simulation

Dimitrios Stiliadis, Anujan Varma

January 1997 **ACM Transactions on Modeling and Computer Simulation (TOMACS)**, Volume 7 Issue 1

Full text available: pdf(925.18 KB) Additional Information: full citation, references, citings, index terms, review

Keywords: ATM switch scheduling, field-programmable gate array, hardware simulation

14 On fundamental tradeoffs between delay bounds and computational complexity in packet scheduling algorithms

Jun Xu, Richard J. Lipton

August 2002 **ACM SIGCOMM Computer Communication Review , Proceedings of the 2002 conference on Applications, technologies, architectures, and protocols for computer communications**, Volume 32 Issue 4

Full text available: pdf(323.74 KB) Additional Information: full citation, abstract, references, citings, index terms

In this work, we clarify, extend and solve an open problem concerning the computational complexity for packet scheduling algorithms to achieve tight end-to-end delay bounds. We first focus on the difference between the time a packet finishes service in a scheduling algorithm and its virtual finish time under a GPS (General Processor Sharing) scheduler, called GPS-*relative delay*. We prove that, under a slightly restrictive but reasonable computational model, the lower bound computational c ...

Keywords: computational complexity, decision tree, delay bound, packet scheduling, quality of service

15 Trace-driven modeling and analysis of CPU scheduling in a multiprogramming system

Stephen Sherman, Forest Baskett, J. C. Browne

December 1972 **Communications of the ACM**, Volume 15 Issue 12

Full text available: pdf(677.58 KB) Additional Information: full citation, abstract, references, citings

Microscopic level job stream data obtained in a production environment by an event-driven software probe is used to drive a model of a multiprogramming computer system. The CPU scheduling algorithm of the model is systematically varied. This technique, called trace-driven modeling, provides an accurate replica of a production environment for the testing of variations in the system. At the same time alterations in scheduling methods can be easily carried out in a controlled way with cause an ...

Keywords: CPU scheduling, multiprogramming, performance measurement, scheduling, trace driven models

16 Non-clairvoyant scheduling

Rajeev Motwani, Steven Phillips, Eric Torng

January 1993 **Proceedings of the fourth annual ACM-SIAM Symposium on Discrete algorithms**

Full text available: pdf(1.19 MB) Additional Information: full citation, references, citings, index terms

17 Fair scheduling in wireless packet networks

Songwu Lu, Vaduvur Bharghavan, R. Srikant

August 1999 **IEEE/ACM Transactions on Networking (TON)**, Volume 7 Issue 4

Full text available: pdf(275.27 KB) Additional Information: full citation, references, citings, index terms

18 Effective distributed scheduling of parallel workloads

Andrea C. Dusseau, Remzi H. Arpaci, David E. Culler

May 1996 **ACM SIGMETRICS Performance Evaluation Review , Proceedings of the 1996 ACM SIGMETRICS international conference on Measurement and modeling of computer systems**, Volume 24 Issue 1

Full text available: pdf(1.80 MB) Additional Information: full citation, abstract, references, citings, index terms

We present a distributed algorithm for time-sharing parallel workloads that is competitive with coscheduling. *Implicit scheduling* allows each local scheduler in the system to make independent decisions that dynamically coordinate the scheduling of cooperating processes across processors. Of particular importance is the blocking algorithm which decides the action of a process waiting for a communication or synchronization event to complete. Through simulation of bulk-synchronous parallel a ...

19 Router plugins: a software architecture for next generation routers

Dan Decasper, Zubin Dittia, Guru Parulkar, Bernhard Plattner

October 1998 **ACM SIGCOMM Computer Communication Review , Proceedings of the ACM SIGCOMM '98 conference on Applications, technologies, architectures, and protocols for computer communication**, Volume 28 Issue 4

Full text available: pdf(1.82 MB) Additional Information: full citation, abstract, references, citings, index terms

Present day routers typically employ monolithic operating systems which are not easily upgradable and extensible. With the rapid rate of protocol development it is becoming increasingly important to dynamically upgrade router software in an incremental fashion. We have designed and implemented a high performance, modular, extended integrated services router software architecture in the NetBSD operating system kernel. This architecture allows code modules, called *plugins*, to be dynamically ...

Keywords: high performance integrated services routing, modular router architecture, router plugins

20 Dynamic core provisioning for quantitative differentiated services

Raymond R.-F. Liao, Andrew T. Campbell

June 2004 **IEEE/ACM Transactions on Networking (TON)**, Volume 12 Issue 3

Full text available: pdf(517.92 KB) Additional Information: full citation, abstract, references, index terms

Efficient network provisioning mechanisms that support service differentiation are essential to the realization of the Differentiated Services (DiffServ) Internet. Building on our prior work on edge provisioning, we propose a set of efficient dynamic node and core provisioning algorithms for interior nodes and core networks, respectively. The node provisioning algorithm prevents transient violations of service level agreements (SLA) by

predicting the onset of service level violations based on a ...

Keywords: capacity dimension, point-to-multipoint congestion, service differentiation, virtual queue

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